



**THE CARE OF
ORNAMENTAL TREES**



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THE CARE OF ORNAMENTAL TREES

IN

*Planting, Fertilizing, Pruning, Tree
Surgery, and Spraying*

BY

C. F. GREEVES-CARPENTER

F.R.H.S., F.E.S.

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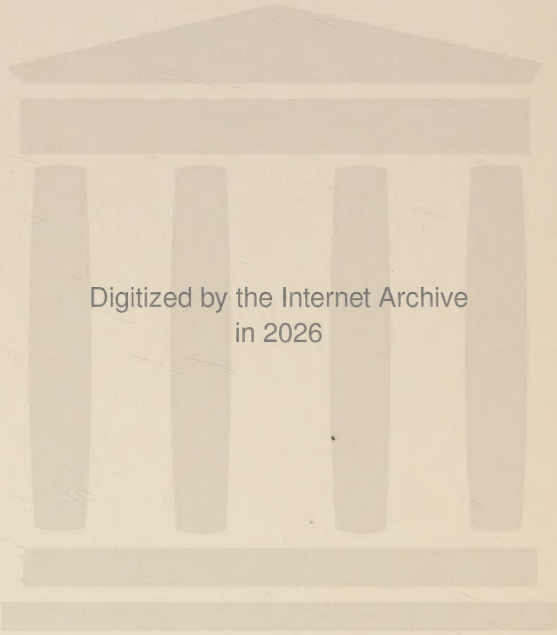
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TO
MY WIFE

WHO HAS BEEN MY GREATEST HELP AND
ENCOURAGEMENT IN ALL MY WORK



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ACKNOWLEDGMENT

THE photographic illustrations in this book were taken at the West Laurel Hill Cemetery, Philadelphia, Pennsylvania, to which company I wish to express my appreciation of their courtesy. This particular cemetery has a wide variety of trees, a number of which have received treatment over a period of fifteen years, and the photographs were taken there as showing a representative estate.

INTRODUCTION

MANY volumes have been written about trees, but few books have dealt with every phase of their care. Tree surgery is one of the young sciences which, through research, is fast developing, and in the near future it may be that it will be possible to make definite assertions for the care of each species and variety of tree. In the meantime, however, it is impossible to do so, as it is realized by tree workers that each species, and almost each individual tree, is a law unto itself. So many factors bear upon a given condition in a tree that until these have been thoroughly investigated and tabulated one can follow only certain general principles in guarding tree life.

It is only in recent years, for instance, that nurseries have eliminated trees that are unsuited to the climate in which it was proposed to grow them. This was a step forward which could be made only after years of experience.

Manure and dirt used to be the materials used for filling cavities. Now, as the result of the development of the science of tree surgery, there are numerous filling materials on the

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market all of which possess some merit, though naturally some possess more than others. A description of the various methods of cavity treatment and filling media is given under a separate chapter.

Feeding trees with commercial fertilizers is fast attaining to a point where an expert can tell exactly to what materials or chemicals certain trees will best respond under specific conditions.

Tree surgeons are undoubtedly giving of their best to the trees and to the public, and should receive every encouragement and confidence. The one stigma against the profession is justified when a so-called "tree expert" is consulted, gets a job because he either has a glib tongue, or gives a cheaper estimate. Invariably such men (and they are in all branches of professional and commercial work) do poor work and give the professional tree worker—the college man who has spent several years studying tree conditions—a very poor chance. Some of the states have passed laws making it compulsory that every one engaged in commercial tree work should pass an examination by a State Tree Examining Board, and in states where this law is enforced unskilled workers are eliminated and this does much to protect trees and their owners from "graft."

This book is written with a view to giving the tree owner, who cannot possibly know all the

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developments and the pitfalls in tree surgery, a ready method of checking the work done on his place, and, in a measure, to help him do some of the work himself should he be interested. Unfortunately, the tree owner cannot do spraying because it would not be profitable to keep the necessary power equipment to spray big trees unless he has a very large estate; he cannot do cavity work because he does not have either the necessary equipment or the very essential knowledge of what each type of cavity requires; and, as a rule, the tree owner would not wish to attempt pruning, particularly the tops of high trees.

My thanks are due to Mr. H. Gleason Mattoon, in charge of the Tree Department of Harrison, Mertz & Emlen, Inc., and to Mr. Norman K. Morse, of Morse and Morse, both of Philadelphia, Pennsylvania, for reading the manuscript and for much helpful criticism, and to Mr. Herman Hornig, curator, the Public Museum and Art Gallery, Reading, Pennsylvania, for the illustrations of a section of tree and for the one on pruning.

C. F. GREEVES-CARPENTER.

Philadelphia, Pennsylvania,
November 1, 1927.

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Their Planting and Care

BEFORE one can intelligently do tree work or diagnose with some degree of accuracy the many ailments, diseases, or insect pests to which trees are subject, it is necessary to know something first of the trees themselves.

A tree is a plant having a single trunk which is woody and branched. From the accompanying illustration it will be seen that the trunk of a tree consists of four usually distinct sections. (Fig. 1.) In the center is the heartwood, which is corelike in appearance and is usually of a dark texture, though this varies considerably in different species of trees. Surrounding the heartwood is a white wood which is called sapwood. Near the outer edge of this sapwood is a very thin, almost inconspicuous, layer termed the cambium, and protecting this is the bark of the tree. Each of these four sections has a definite function.

The heartwood is dead and its sole purpose is to act as a support for the tree. The sap-

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wood is an active portion which carries the sap from the roots to the branches and foliage. The whole growth of the tree takes place in the cambium layer. The cambium is the active tissue of the entire tree, forming wood cells on the inside and bark on the outside. Each year during the growing period it forms an entire new layer of wood, and from the illustration it will be observed that the sapwood is in concentric rings or layers, and as each layer is formed annually it is referred to as an annual ring. It is by these rings that the approximate age of a tree is determined. In some instances two rings may be formed in one year.

During spring, which is the active growing period for trees, the flow of sap is very plentiful, but toward fall it is less abundant, and the outer bark adheres tightly to the cambium, remaining in this condition throughout the winter which is the dormant period.

The bark protects the thin, tender cambium layer from injury, and through certain vessels there is a flow of sap in which food manufactured in the leaves is transported to the roots. The bark serves also to protect the cambium from extremes of temperature, and from too rapid an evaporation of water.

As every one knows, the bark of different trees varies in texture. On the beech, for instance, it is thin and flintlike, on the cedars it is loose and threadlike, on the cherry it is

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smooth, on the shellbark hickory it peels in long strips, on the sycamores it peels in thin scales, making a blotched appearance on the trunk, and on the oaks it splits into irregular, longitudinal furrows. In fact, the bark is so different in the various trees that, together with the branching system, it forms a ready means of identification when the trees are denuded of foliage.

Disease does not readily enter trees whose bark is unbroken. When the bark is injured so deeply that the cambium layer is exposed, the time to apply what knowledge one possesses of tree surgery has arrived.

The branch system is made up in the same manner as the trunk: that is to say, of heartwood, sapwood, cambium, and bark. The actual branching system of trees varies considerably, as may readily be observed. In some trees like the weeping beech the branches droop, but the maples have their branches opposite each other, the young poplars have their branches shooting upward almost parallel to and very near the trunk, the ginkgo has its branches in whorls, while the branches in the elms are arranged alternately, and so on.

The growth in length is accomplished at the end of each branch, and this also applies to the trunk of the tree. In the case of the trunk, for instance (to illustrate the above point), an injury on a one-year-old tree one foot from

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the ground would be in exactly the same position after the tree had attained its full height.

At the end of each small branch there is a bud which grows upward and increases in length during the growing season of early spring and summer. When the leaflets cease to open a winter bud is formed, and the branch then continues to grow in thickness only. The so-called winter buds are formed during the summer, though the actual time of formation of these buds differs in the various species.

The leaves are a very important part of the trees, as they actually manufacture much of the food with which the wood structure is made. There is a direct relation between the volume of foliage and the wood structure, and, therefore, every branch severed from the tree deprives that tree of a proportion of food-supplying foliage.

The flowers and fruits (seeds) of trees vary considerably in size, design, and color. Nearly every one is familiar with the flowers of the flowering dogwood, tulip (popularly known as tulip poplar), magnolia, and horse-chestnut, besides a number of other trees bearing prominent flowers, but there are many other trees, the beeches, for example, in which the flowers are obscure. The fruits or seeds of some trees are more prominent than in others. The winged seeds of the maples, the acorns of the

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oaks, and the catkins of the poplars are familiar to all.

Seeds dropped by a tree under its own branches will rarely germinate, as the ground is reserved and occupied by the parent tree. The distribution of seeds may be said to be dependent upon birds, small animals, wind and flowing water.

Seeds of trees behave differently in germinating, but nearly all first form a type of root which goes down into the ground, and this is known as a tap root. Lateral roots shoot out from the crown, and these are termed prop roots, as they fix the tree in the ground; these prop roots also assist in carrying moisture. From the lateral roots extend many hundred fine rootlets, termed fibers or fibrous roots and these are the feeding roots.

Many trees will take root from cuttings, and some are very easy to propagate by this means, particularly willows, poplars, and catalpas. Other trees have a tendency to send up sprouts from their roots, and among this class may be mentioned the silver poplar, ailanthus, and locust trees.

The life of a tree depends to a large extent upon the care taken in transplanting. Often the roots are cut to make it more convenient to handle, and with the lateral cut go many of the fibrous roots upon which the tree depends for nourishment. The roots are large near the

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trunk and taper to a fine point quite a distance from the trunk, depending upon the type of tree. These large lateral roots divide and subdivide into innumerable fibrous roots, which are very small and very tender.

In removing trees the utmost importance should be attached to preserving the fibrous roots, and as these may nearly all be near enough to the trunk to be removed with the tree, the large lateral prop roots may be cut when necessary just closely enough so that they may still function as prop roots. The fibrous roots in nursery stock are apt to be much nearer the bole than is the case with forest trees, as transplanting increases the number of fibrous roots in closer proximity to the trunk.

Certain trees, such as the tulip and sassafras, are much more difficult to move successfully than others. There are companies which specialize almost exclusively in big tree moving, and, when practicable, they should be employed in preference to less experienced and ill-equipped men.

In many instances it is necessary to prune or cut back the top growth considerably in order to restore a balance between the root and branch systems, as the former may have been injured to such an extent that the top growth would make too heavy a demand upon the attenuated or limited root system.

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With old, established shade trees the root system is in many cases very extensive and very intricate. It will, in some instances, extend some distance beyond the branch spread, and in other cases it will be more concentrated toward the trunk of the tree.

Some species of trees grow much more rapidly than others, but they always attain their maximum height at an early age and well in advance of their maximum diameter growth.

There are two types of trees; the evergreens, the foliage of which is, as their name implies, ever green, and the deciduous trees, which shed their leaves annually. Actually most evergreens drop their leaves from every two to four years, so there is always foliage on this type of tree. The new foliage of the evergreens is readily distinguishable in the late spring by its light shade of green.

The planting scheme will depend largely upon its purpose, *i.e.*, whether to form an avenue over a driveway, a windbreak, an ornamental grouping, to hide an unsightly outbuilding, or to offset some feature of the landscape. There are hundreds of species and varieties of trees from which a choice may be made, and, properly grouped, the planting will be an object of beauty.

Having decided the purpose of the planting, the next question is the type of tree or trees. These can best be chosen by having regard to

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such points as their suitability to the local soil conditions, the climate, exposure, shape of the crown, length of life, ornamental features, type of root system, etc. With regard to the last point: it is not advisable to plant trees that are shallow-rooted in positions where the roots would spread out under concrete, for then they would be apt to crack and upheave the concrete.

Some surface-rooted trees are the poplar, Norway maple, elm, some of the oaks, and the tulip tree, and some of the deep-rooted trees are the red maple, sugar maple, ash, pine, and other oaks.

Some trees are much better suited for city-street planting than others; some (though these are few) are better able to withstand the fumes from factories, etc.; some make excellent individual specimens on lawns, and still others lend themselves to artistic grouping.

Some of the trees more suited to city streets and gardens are the Oriental plane, American ash, American elm, European linden, ginkgo, and ailanthus. The last named is not, perhaps, a very desirable tree, except that it will grow under conditions that would generally be detrimental to plant life. Obviously, some trees that would be suited to conditions in California could not be grown in the East. For a detailed list of trees suitable for planting in the different regions, Farmers' Bulletins Nos. 1208 and 1482

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of the United States Department of Agriculture, Washington, D. C., may be consulted.

The majority of large nurseries maintain a landscape department, and the salesmen employed by nurseries usually have, besides their actual selling experience, a knowledge of trees, and are qualified to give advice to prospective purchasers as to the suitability of trees for certain purposes. Any good book on landscape architecture should also be consulted for ideas on planting.

Trees should not be obtained from a forest, as their root system is usually very extensive, and, as a result, by far the greater proportion of their fibrous roots would naturally be destroyed in transplanting. With nursery stock it is an altogether different matter. Good, deep, fertile soil is supplied to the trees in nurseries, and by judicious transplanting the trees have a distinct tendency to grow their roots in a more compact form than forest trees; as a result less injury will be done the root system in their final transplanting. Again, nursery stock invariably produces straight trunks, with small symmetrical crowns, and well-developed leaders.

Trees may be transplanted at any time after the ripening of the summer growth and before the opening of the buds. In the fall the soil is warm and the air cool, and a rapid growth is promoted, so that the tree transplanted in fall takes a firm hold in the soil before winter sets

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in. In spring the root growth is slower, and there is a tendency for the buds to develop too rapidly. This, however, is counteracted by heavy pruning to strike a balance between the roots and the top growth.

Great care should be taken with the roots of evergreens, because if they are injured to an appreciable extent it would be necessary to shear the branches in spring before new growth starts.

It is always safer to have the holes dug in advance of the expected arrival of the trees. The holes should be made large enough to take the entire root system without any doubling back or twisting of the roots. The valuable properties of well-rotted liquified barnyard manure or cow manure are quickly assimilated—either should be used in preference to a commercial fertilizer with newly planted stock. A bone meal with an analysis of $4\frac{1}{2}$ per cent ammonia and 50 per cent boned phosphate of lime is the best grade to use for tree food for the second and third years, as it will release the nutrient salts more slowly, and over a longer period of time than a bone meal having a lower analysis.

From the time a tree leaves the nursery until it is finally planted, the roots should not be exposed to the sun or dry air, but should be kept moist and covered. All injured roots should be removed with a sharp instrument, the



FIG. 2. Top of tree dying back due to girdling roots as shown in Fig. 3.



FIG. 3. Girdling roots on maple.

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cut being made obliquely, and the wound promptly painted with a tree-wound paint. Any injured branches should also be removed.

Trees should be set an inch deeper than when in the nursery. Once a tree is set in the hole, it should never be twisted in order to line it up with other trees or objects, or for any other reason, as there would be danger of some of the roots girdling.

Some trees seem to have a natural tendency to commit suicide by root girdling, and in others this is engendered by twisting the tree once it has been set. In girdling, the root or roots twine around the trunk, drawing tighter and tighter, until they cut into the sapwood, cut off the supply of sap on the side they girdle, and the tree dies back on the affected side. An illustration of this is shown in the two photos of a maple, one of which shows the girdling root, and the other the top of the same tree dying back. Little can be done to save this particular tree, as it is almost too far gone. (Figs. 2 and 3.)

In cases like the above, the girdling roots should be removed with a sharp chisel, the wound should be painted with a tree-wound paint, and the trees should then be fed and watered. Care and attention in the early stages will prevent serious injury, and the ultimate and untimely death of the tree.

Not all girdling roots will kill a tree, or even cause it to die back, however, as in some

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instances a natural union will take place between the cambium layer in the girdling root and that of the trunk of the tree, and the supply of the sap will only be somewhat diverted.

Girdling roots will usually be noticed on the surface of the ground, invariably close to the trunk of the tree. Trees, however, never seem to follow any rule. These strangling roots may be under the surface of the soil, cutting into some of the lateral roots above, or, at least, in such a manner that they will retard or even eliminate the flow of sap from the majority of fibrous-feeding rootlets on that particular lateral or prop root.

The soil should be compacted about the roots of newly transplanted stock, care being taken that no "pockets" are formed, and that all the roots are in direct contact with the soil. Watering will assist in compacting the soil, but it must be remembered that too much water will cut off the air supply. If the weather is hot and dry, it would be as well to mulch the surface with straw or manure after watering, as that would tend to conserve the soil moisture. The mulching will prevent frost from penetrating the ground in the winter. As field mice are apt to girdle trees when other food is scarce, particularly where there is a mulch, a wire collar should be placed around the base of the tree.

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Young trees, particularly those planted in exposed positions, should be provided with a support to keep them firm; this will assist the roots to take hold of the soil. A stout stake should be driven into the ground close to the trunk, and the tree should be securely fastened to it in three places by means of rope passed through some old garden hose. It is important to stake old trees after transplanting, and the usual method is to fasten three guy wires to stakes. Trees in positions where they may be injured by lawn mowers or by other mechanical means, should be protected by a tree guard, of which there are many serviceable types on the market.

In transplanting evergreens it must be remembered that they are continually covered with foliage which needs moisture, and this must be supplied or the plant will die. Owing to this, evergreens should be moved at a time when the root growth will take place rapidly, and that is when the deciduous trees are commencing to come into foliage, continuing for about three months, or else not until the fall rains, continuing until about a month before heavy frost occurs. Evergreens require plenty of water during autumn. A light mulch should be applied when the ground commences to freeze, and this should be removed in the spring as soon as the ground thaws.

Evergreens are usually delivered from the

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nursery with a ball of earth around their roots, and this is wrapped in burlap, which should be removed before planting. The tree should be planted, good earth firmed down over the roots, the ground watered, and after the water has soaked in, some loose soil should be raked over the surface.

After transplanting evergreens—and this applies particularly in arid regions—it is best to sprinkle the foliage of newly transplanted evergreens daily, or as often as local conditions make it practicable, as this will reduce the evaporation from the foliage considerably. A screen placed on the windward of these trees is another great help in checking evaporation.

Freshly planted trees that have come from a protected place are apt to suffer from sun scald when placed in an exposed and unprotected position. This may be prevented by wrapping burlap around the trunks of newly transplanted trees. Where this precaution has not been observed the sun scald may kill the living cells in the cambium, and, in severe cases, the bark will crack vertically and peel. This is due to sudden change of temperature, and a drying out or shrivelling of the cells. These injuries form excellent hibernating spots for insects, and at the same time expose the cambium to infection, and to wood-destroying agents. Sun scald cracks should have all the loose bark scraped away, and the cambium

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should be cut with a sharp knife or chisel to a V-shape at the top and base of the split, and, when dry, the cambium should be shellacked. The exposed portion of the tree should then be painted with a tree-wound paint. If this treatment is neglected the tree will soon have a cavity, and the top, at least on the affected side, will die. Sun scald with transplanted trees is partly due to the partial removal of the roots during transplanting with a consequent lessening of the arteries which would ordinarily collect and transport moisture throughout the tree.

After trees have become established, certain precautions must be observed if it is desired to regrade the land in the vicinity of trees. Such an operation will change the water-securing properties of the soil, the amount of air that can penetrate to the roots, and the amount and character of the microbe life that functions in the soil. When the fill is a deep one the air supply is practically cut off, the microbe life is smothered in the old surface soil upon which the roots depend for food, and the roots die. Also, when the earth is filled in immediately around the trunk it will cause the latter to rot.

Some trees are able to adjust themselves to regrading conditions, but they are exceptions. Much may be done, however, to help trees adjust themselves to regrading. On the old soil surface stone drains should be laid connecting

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with each other and with the open air after the fill has been made, so that there is a continuous circulation of air through them. Further, a well should be made around the trunk from the old soil surface to the top of the new surface, and this well should be kept free from leaves and rubbish. The greatest danger from regrading and mounding up of soil around a tree trunk is from the compacting of the fresh soil which, pressing on all sides at the base of the tree, prevents its increasing girth, hence the necessity for a well. These two precautions provide for the aëration of the soil, and prevent the trunk from coming into direct contact with the newly filled-in soil which might otherwise cause it to rot.

Pruning

The general public seems to consider that pruning is a yearly need of trees; such, however, is not the case. Trees can be pruned too much, as well as not enough.

There are three main reasons why and when pruning should be done:

1. When transplanted, trees may require cutting back in order to balance the top growth with the root system which may have been injured during transplanting, or to develop a leader, or to remove valueless interior branches, and deciduous trees which have been moved should have the tops thinned.

2. Trees should be pruned when they are planted too close to each other, so that their branches do not interfere.

3. When trees are weakened by decay, have diseased or dead limbs, or the top growth is too heavy to be adequately supported by the root system.

Besides the above reasons, it may be desirable to reshape a poorly shaped crown, or to open up a vista through a line of trees.

Pruning time may be said to be any time, except in the early spring or early fall when

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excessive bleeding might take place. Maples and birches are, perhaps, the most likely to have heavy bleeding induced if pruned at those seasons of the year.

If trees are pruned immediately prior to the growing season, the pruning cuts will be practically or completely covered by the "roll" or growth of the cambium. In case of small pruning cuts on vigorous trees, the pruning wounds may be entirely healed over at the end of one season.

As has been previously stated, when nursery stock has been transplanted it is invariably necessary to cut back the crown in order that the top growth may not be too heavy for the root system to support. With this cutting back of the crown a balance is struck between the branch and root systems, and, given normal conditions, the tree should grow quite vigorously. This procedure also helps to secure a stronger and more vigorous growth, as when one living limb of a tree is removed the food supply which it would have drawn from the roots is distributed over the rest of the tree.

The pruning required by young trees is the cutting back of over-vigorous growth, the removal of crowding branches, and an upright shoot, or leader, should be encouraged.

Very often trees are planted too close to each other or too near buildings, with the result that their branches interfere with each other or with

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the buildings. These interfering branches should be cut out entirely, as, with but few exceptions, it is bad policy to trim the ends of branches. Branches of deciduous trees which hang too low should be cut back to the main trunk or large limb.

In many instances limbs of street trees will be in the way of electric wires, and it is then necessary to prune the tree in order that it will be induced to carry its crown above the wires, though in some cities it is compulsory to have the tops of the trees cut back four feet lower than the wires. The former is usually done by removing all but three or four of the most vigorous limbs. It is not advisable to cut the entire top of the tree below the overhead wires, except where necessary for shaping. With the cutting off of the top, the heartwood of the tree is exposed to rot and to wood-destroying agents with the result that, depending on the variety of tree, large cavities are soon formed. Soft-wood trees, such as the maples, form cavities much more quickly once the heartwood is exposed than hardwood trees such as the oaks. No amount of treating the wounds with pruning compound or tree-wound paint is as effective as scientific pruning to avoid unnecessary pruning wounds.

The inner branches of trees should always have sufficient light and air, and it is often necessary to thin the trees in order to achieve

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this object. The Norway and sugar maples have particularly dense crowns, with the result that these trees are often overbalanced between the root and branch systems, and they often wilt due to their dense foliage drawing too heavily upon the soil fertility and moisture. The superfluous branches should be removed by judicious pruning which will preserve the natural form and beauty of the trees, and at the same time cause them only to produce as much foliage as their root system can adequately support. Practically all deciduous trees on lawns tend to have too dense a crown, and these should be judiciously thinned.

In the case of Norway maples, excessive transpiration will cause these trees to shed their leaves rapidly. The ground is soon covered with foliage, and, in this manner, Nature helps to adjust an over-abundance of foliage. Nature seems haphazard, however, and it is by far the better plan to thin the inner-branch system.

Trees that are not properly trained in the nursery to develop a single shoot or leader, produce instead two main shoots from the point of branching. Nurseries take great care to develop the leader of pin oaks, Lombardy poplars and certain other trees whose characteristics are a simple straight trunk. Pruning the leader on such trees will result in a double or triple top. In some instances this forms a sharp V-shape

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and, naturally, as the tree develops, and as the union at the point of the angle is scarcely ever perfect, the tree splits when undue strain is put on the weaker branch, as frequently occurs during heavy wind or ice storms. Other trees develop, instead of a sharp angle, a U-shape fork and these are very much stronger than the V-shape fork, because the strain at the crotch is more equal than it could possibly be with a sharp angle.

This method of branching into two main structural branches which subdivide to form the head is characteristic of elms and silver maples, but by early training, with judicious pruning, the branching system should be developed so that from three to five equal-sized structural branches are formed, and these will then subdivide and form a good head or crown, with the advantage of increased structural strength. The head or leader should not be cut back on certain trees, such as white maples, English elms, lindens, etc. Where the proper training of a tree has been neglected, and it has developed a two-branch system, it is always advisable to have these two main arteries bolted, as this will tend to prevent their splitting at the fork or crotch; the heavy limbs should also be cabled together.

In pruning, as in fact with nearly all work connected with trees, definite, positive statements cannot be made, particularly in regard

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to trees in general. A real tree expert examining any tree can, from his wealth of experience and training coupled with his observations, make an accurate diagnosis as to the condition of the tree about which he may be consulted, but in a book only general fundamental principles governing the care of trees can be set forth.

Cavities in trees are largely due to neglect, and to pruning done by cheap, inefficient, unskilled labor. Pruning is an art which cannot be accomplished by any one capable merely of handling a saw.

Spurs used to assist in climbing should in all cases be prohibited as they do much injury to the tree. A proficient tree worker uses a rope adjusted about his waist and fastened to a stout limb above. The knots are so made that the worker may move up and down at will, and be properly safeguarded as well.

The pruning of a tree is usually done from the top downward, as in this manner the desired form may be better obtained.

Pruning cuts should not be made even with the trunk of the tree, as the long cut then necessary frequently decays before it properly heals. The cut should be made at the "collar" which does not leave a stub, but will facilitate healing of the cut. (Fig. 4.) Large branches require at least three cuts to be made. The first cut should be from the under side of the branch

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about two feet away from the trunk. This cut should be made toward the upper side of the limb until the saw will not work on account of binding. Then the sawing should be started about a couple of inches beyond the first cut, but this time the cutting should be from the upper to the lower side. The weight of the branch will soon cause the lower and upper cuts to meet as the pressure it exerts will cause it to break off. A third cut should then be made through the collar on the trunk or main limb in order to remove the stub, which should be held firmly until sawed through in order to prevent its splitting or tearing off some of the bark. The cut should be clean and, owing to the limb being taken off at the collar, the resulting wound will be more or less oval in shape.

All pruning cuts over two inches in diameter should be painted with a pruning compound or tree-wound paint, as this material is usually antiseptic and, if renewed yearly, should stop the wound from decaying. The pruning paint should not be painted over the cambium, as it would be likely to kill the living cells.

The cambium layer in normal, healthy trees soon starts to heal over the pruning cuts, and, if the wounds are small ones, the cambium may entirely cover them in one growing season.

Pruning wounds over three inches in diameter ought to be treated as cavities, although that has not been the general practice in the

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past. It is a recognized fact that the pruning compound will not be indefinitely effective in preserving any surface that the tree has not healed over, and for this reason large pruning wounds should have the wood removed to a depth of two inches, and this small cavity filled. This, providing a suitable filling medium has been used, will prevent the entrance of insects, wood-destroying agents, and decay. The cost of treating the larger pruning wounds as cavities will be slight, and as it permanently protects the tree it will prevent the formation of large cavities and the possibility of increased expense. Small pruning wounds, and these are well in the majority, will invariably be healed over by the end of the second growing season.

White lead or any lead base paint is inadequate for treating tree wounds as neither has any elasticity, and both will crack with changes of temperature. Without some preservative material on the surface of wounds, the wood loses moisture and cracks, making an easy entrance for bacteria and other wood-destroying agents.

Dead limbs should always be removed from trees, as they are not only unsightly, but are an actual source of danger to life and property. Deadwood should be removed by cutting back into the good, live tissue.

Broken limbs should receive prompt atten-

Pruning

tion, the stubs should be removed as described above, and the wounds painted.

The lower branches of evergreens should not be removed unless this is absolutely essential by reason of their being broken or diseased, as most of the evergreens are pyramidal in shape and depend upon the lower branches to accentuate their outline.

Bud pruning may be done to advantage in conifers to preserve their shapeliness. The center buds from any shoots that project out of proportion with the rest of the tree should be clipped off. In order to thicken up pines with sparse foliage, the terminal twigs of each branch may be clipped off before the trees make their growth in the spring. Pruning shears should be used for this delicate operation.

Those branches which are overladen and show signs of splitting at the crotch are best supported by means of bolts and cables.

Chains are conspicuous and will rust unless painted regularly. Wire cable of $\frac{1}{4}$ -inch or $\frac{3}{8}$ -inch 7-strand is stronger, rust proof, and inconspicuous.

This operation is comparatively inexpensive, and undoubtedly saves a greater expense in preventing splitting and possible formation of a cavity. In the case of a tree with a sharp V-shape crotch, the union is never perfect so that the strain on the two limbs is not equally

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divided. A hole should be bored through the two limbs, and a strong bolt passed through and fastened on the outside by a washer and nut countersunk in the bark. It may be advisable to have two bolts several feet apart placed through the limbs in order to protect the tree adequately. These bolts or rods are to be preferred when rigidity is required, but where several branches need to be fastened together in the crown of the tree, cables should be used, as the factor of flexibility is more important than that of strain.

In using cables it is necessary to bore holes through the limbs, and to use bolts which have a hook, on the one end, and the usual thread, washer and nut on the other, in order to support the cables. The washer and nut should be countersunk in order that the cambium may heal over them.

Bands of any description or wire should not be used, as, in time, they would become imbedded in the bark and cambium, and the sap supply would then be cut off from the top of the tree.

Fertilization of Shade Trees

The natural environment for trees is the forest where the conditions are ideal, and it is reasonable to assume that when the first settlers landed in this country they found an almost perfect tree growth. With the advent of civilization there came, however, a destructive campaign in order to build suitable habitations. Roadways were cut into virgin forests, land was cleared, until finally there developed conditions as they are to-day: flourishing and prospering for the people, unnatural and devitalizing for the trees.

Trees are able to supply themselves with nourishment in the woods and forests by the natural shedding of their foliage, which settles on the ground, retains moisture in the soil, and, with the action of the elements, decomposes, forming a rich leaf mold upon which the trees feed the following spring.

On estates, lawns are kept neatly swept. Estate owners spend large sums to achieve *natural* and pleasing effects in planting, but they do not permit the natural health-giving food which, in its decomposition, forms a beautiful carpet to remain on the ground. There is scarcely any one who does not love to walk

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through the woods in autumn, when the foliage in changing color varies from red to gold, and flutters to the ground, forming a carpet of crisp, dry leaves. What more pleasing effect is there that Nature gives us yearly? We owe it to our own enjoyment and to the health of our trees to allow the leaves to remain on the ground.

There are, however, many tree owners who would not agree to the suggestion that their lawns should be "littered" with leaves, and for them a commercial fertilizer is an essential substitute with which the trees may be properly fed.

Ten elements essential to plant life are: hydrogen, oxygen, carbon, nitrogen, sulphur, phosphorus, potassium, magnesium, iron, and calcium. The plants obtain carbon from the atmosphere. Five other elements, hydrogen, oxygen, magnesium, iron, and calcium, are present in the majority of soils, and the remaining four elements, nitrogen, phosphorus, potassium, and sulphur, are the elements which are most readily exhausted.

Hydrogen, combined with oxygen, forming water, is essential to all plant life, and is present in all plants in quantities upward of fifty per cent of their total weight. It is in the form of water that trees get most of the hydrogen and oxygen which helps to make up the tissue, starch, sugar, etc.

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Carbon occurs as part of the organic matter in soil. United with calcium and magnesium it forms carbonates, and combined with oxygen it forms carbon dioxide, one of the soil gases, and this, dissolved in soil water, plays an important rôle in the assimilation of plant food. The carbon utilized by plants, however, is derived from the free carbon dioxide in the atmosphere.

Nitrogen is abundant enough in the atmosphere, but it is from the nitrogen in the soil that plants take some of their sustenance. In soil it occurs as a composite of humus and decaying animal and vegetable tissues, and through the agency of bacteria this is converted into nitric acid, and this combining with other ingredients forms a soluble salt.

Sulphur occurs in soils combined with iron or as a sulphate in combination with iron, lime, or magnesia. It is a necessary part of the organic compounds in the tissues of plants.

Phosphorus is never found in the soil unless combined with some other substance and is an essential soil chemical.

Potassium is another essential element for plant nutrition, and is widely distributed, but in combination with other elements that are highly soluble, and, on account of the ready solubility, soil soon becomes depleted of potassium owing to leaching or draining away.

Magnesium and calcium are metals which

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are usually present in abundance in all soils, and both are indispensable to successful plant growth.

Iron is an abundant ingredient of most soils, and as it is not readily soluble there is never a deficiency.

There are many commercial fertilizers on the market, all of which contain the necessary elements to stimulate and support plant life, but some of the commercial fertilizers are better than others in that the formulæ are composed of materials which will give off or release the nutrient salts over a long period of time. That type of fertilizer is much better than those containing materials which readily release the nutrient salts.

It is not necessary to pay a high price for a fertilizer. There are many very reliable commercial concerns which put up excellent tree food at moderate prices.

The trees cannot, of course, take up the solid particles of food that are placed in the ground, and it is only by the action of moisture that the chemicals are converted into liquid form and the trees enabled to avail themselves of the nourishment.

There are several methods of feeding trees. One is to dig a trench under the extremities of the branch spread. This is not to be recommended, however, as many of the feeding rootlets must naturally be destroyed by such a

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method, and it has another distinct disadvantage in that it takes more time and material. Another method is to distribute the fertilizer on the top of the soil, but the chief objection to this is that it tends to attract the feeding rootlets to the surface in their endeavor to take advantage of the food, and there they are apt to dry out; moreover by this method the grass may be burned by the chemicals, and there would also be a large amount of waste by leaching. The best method is to place the food in a position where the feeding rootlets will be able to receive direct benefit, and where there would be no undue waste of material.

The construction of the root system of a tree is much the same as its branch system. The roots extend slightly farther in the ground than the farthestmost branches extend in the air. Generally the feeding rootlets will be found about eighteen inches under the surface. A number of holes should be made either with an auger or crowbar, in a circle about two inches beyond the branch spread. These holes should be eighteen inches deep and two feet apart. A second circle of holes should be bored midway between the outer circle and the trunk, but not nearer than six feet to the trunk. The holes should be filled with the fertilizer up to within four inches of the surface and the sod should then be pushed back into position. In this way

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there will be no danger of spoiling the appearance of the best lawn.

It is practically impossible to determine the quantity of fertilizer required by any tree: some trees have a very extensive root system, and in others it closely approximates the branch spread.

The crowbar method of feeding serves a dual purpose in that besides forming a receptacle for the food, it aërates the soil.

Many gardeners recommend stable manure for trees. It makes a good humus and greatly improves the physical condition of any soil, but it does not feed the trees properly, particularly if it is broadcasted on the surface. Liquified barnyard or cow manure is excellent for newly planted or transplanted stock.

When shade trees have been properly fed, it is not necessary to feed them every year unless exceptional conditions prevail. Every three years after the first application should be often enough for refeeding, to keep the trees healthy and vigorous.

The effects of undernourishment are shown by yellowish or brown undersized leaves, sparsity of foliage, dying back of the tips of branches, and a small annual twig growth. The effects of feeding are readily noticeable. There is an increase in size and volume of foliage, a deeper green color, and a normal, healthy bud and twig growth. The development of healthy,

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vigorous trees tends to check the depredations of insect borers, and there is less likelihood of limbs breaking during storms; consequently, the expense of pruning is greatly reduced.

Soil analysis is excellent in so far as it can determine if any of the essential elements are lacking, when these can then be supplied to the soil in the form of a fertilizer. Further analysis may show that all the essential elements are present, but will not show whether the elements are present in an available form. The United States Department of Agriculture has prepared a list of the soil preferences of many plants, a copy of which should be in the possession of every one going deeply into the subject of correct fertilization. Generally, however, it is quite safe to use a complete commercial fertilizer, particularly as at present no universal plan of diet for different trees has been adopted.

If a tree is growing in soil that is too acid for it, the soil should be treated with lime or limestone which will neutralize the acidity. Analyses would have to be made to prevent too much liming, as this would make the soil alkaline, which might or might not be desirable, depending upon the natural preference of the tree. If it is desired that the soil should be more acid, this may be accomplished by a soil treatment of sulphate of ammonia or tannic acid. The latter is present in acid soil,

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and so should be used in preference to the sulphate of ammonia, as it will be less likely to cause injury to the plants. The sulphate of ammonia is an excellent soil acidifier and works very well in garden loams.

A disadvantage in the use of sulphate of ammonia is that in certain trees, such as the elms and maples, it seems to cause excessive heartwood bleeding or slime flux.

Slime flux is a term which has been and still is indiscriminately applied to all forms of bleeding in trees. Specifically, this condition is a bleeding from the heartwood of the tree and occurs from wounds that penetrate to the heartwood. The slime flux may be colorless or may have a slightly yellow appearance. It has a very bad odor which distinguishes it from ordinary sapwood bleeding. When it seeps down the outside of the tree from a wound or cavity it becomes infected with yeasts which ferment, and a thick, sticky fluid results, whitening the bark. Slime flux is in itself acid, and affected wounds should be cleaned of all diseased wood and treated as cavities, and the soil should be limed in order to counteract the over-acid condition, except in the case of oaks and conifers.

Sapwood bleeding may somewhat resemble slime flux. For instance, many trees have a pocket formation in the crotch or fork of two or more main arteries or branches which will collect rain water. If the crotch splits the

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water will drain away at the lowest point. Yeasts develop and cause decay, and an appearance of slime flux soon occurs. Frost cracks, and other injuries which do not penetrate to the heartwood, will also produce a slime flux appearance, particularly if decay is present.

Sapwood bleeding can be arrested by treating the injured area: that is to say, the cambium should be cut with a sharp instrument so that the injured area is pointed at the top and base, the cambium should be shellacked, and the exposed wood painted with a water-proof or specially prepared tree-wound paint, or the area may be seared with a torch. In normal, healthy trees the healing of the cambium will completely cover the injury, particularly if it is only a narrow one.

Young or ailing evergreens are much benefited by a mulching in late fall with well-rotted barnyard manure, as this gives an excellent stimulus to growth. In conjunction with mulching, it is a good plan to hoe and rake over the surface from the trunk to a couple of feet beyond the branch spread several times during the growing period, as this conserves the soil moisture.

Evergreens are very susceptible to injury from fertilizers. They demand soil rich in nitrogen, phosphorus, and potash, and where evergreens seem undernourished it is as well to remove the topsoil, carefully following the

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root system so as not to injure the fibrous roots, and replace with fresh soil immediately. When the old topsoil has been removed the fresh soil should be filled in at once, as otherwise the roots might dry out. The procedure recommended above was successfully performed on Boston Common several years ago, but as it was done on a large scale, the roots, as soon as exposed, were wrapped with cloths to prevent injury until the new topsoil was filled in. A good practice is to drive a number of holes with a crowbar in order to aerate the soil. A thorough watering would then be of help to the tree. Where possible a water with a neutral reaction should be used. Limestone water is alkaline in reaction.

Trees suffer greatly from lack of water. It will be remembered that trees require hydrogen and oxygen, and that they get this in the form of water, the chemical composition of which, as every one knows, is two parts hydrogen and one part oxygen. Rainfall is not adequate, unless unusually heavy, and the superficial sprinkling given to lawns does not benefit the trees, as this moisture is absorbed by the grass roots. During hot, dry summers the ground around trees, particularly immediately under the branch spread, should be soaked with water every two weeks. Where trees are obviously lacking water, a number of holes under the extremities of the branch spread should be

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made with an auger or crowbar, and the garden hose or water from a bucket put into each of these holes until the ground is puddled. The holes serve also to aerate the soil, a form of cultivation that is very beneficial. Trees that have suffered from lack of water quickly and quite noticeably pick up after each puddling.

Too much water will tend to exclude the penetration of air, and the tree roots will rot. After puddling, the ground should be practically dry within an hour, otherwise it is indicative that too much water has been applied. If practicable, the surface soil should be raked over after watering, as that tends to conserve the soil moisture.

Trees grown on streets and between buildings often suffer from starvation, and it is practically impossible to grow them to advantage between cement walks, roadways or drive-ways, as the amount of soil—the feeding area—is so limited. Incidentally, when the above modern improvements are made, or water pipes, sewers, gas lines, etc., are laid, the roots are invariably cut back, and the top growth then overbalances the root system. Where this is unavoidable, the top growth should be pruned to maintain an equilibrium with the root system, and the affected tree or trees should be fertilized and watered. A tree should always have six square feet or more of uncovered soil at its base, particularly when newly planted.

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After two or three years the ground may be sodded, but concrete or other impervious material should never be laid.

One very important item every tree owner should bear in mind is that a starving tree soon becomes weakened, is less able to withstand storms, and is a prey to insect pests and fungous diseases. Care in feeding and watering is one of the least expensive prescriptions in tree surgery, and will save much money by helping to prevent serious injuries and damages.

The results obtained by proper feeding and watering might almost be said to be in direct proportion to the age and general condition of the trees; young or middle-aged trees respond more quickly than old trees weakened by neglect, disease, and insect pests. It is a comparatively easy matter to keep trees healthy by systematic feeding and watering, and it is certainly much simpler than waiting until the trees are dying from neglect and then attempting to rejuvenate them.

Spraying

It is unfortunate that trees are subject to the attack of insect pests and of fungous diseases. In the majority of instances both the insects and fungi may be combated by the intelligent application of insecticides or fungicides.

There are, of course, many different insects, some beneficial and some injurious. In the insect world there is a continuous warfare being waged between the two classes, and time and again the beneficial ones have won against their enemies, and saved agriculture severe financial losses. One of the most outstanding cases of the pronounced victory of beneficial insects took place in California a number of years ago. The orchards, at that time, were heavily infested with scale insects (the Cottony Cushion Scale) which had inadvertently been introduced into California on some fruit from Australia. The infestation became so severe and so widespread that the citrus industry was seriously affected. Entomologists were sent to Australia, the native habitat of the injurious Cottony Cushion Scale, and one of them discovered a beneficial insect, then unknown in California, a species of ladybird, or ladybug as

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it is sometimes called, the *Vedalia cardinalis*, which attacked the scale insects in Australia. Heavy shipments of these ladybirds to California were at once made, and finding such an abundance of food in the well-established Cottony Cushion Scale, the ladybirds began feeding and reproducing until within a comparatively short period the scale insects came under control.

Many of the injurious insects in this country were inadvertently imported from abroad in shipments of seeds, bulbs, nursery stock, fruit, etc., and, finding an abundance of vegetable food, usually combined with none of their natural enemies, they soon flourished. The United States Department of Agriculture maintains a very strict and effective quarantine system, and rarely is any insect pest now able to get into this country.

There are two types of beneficial insect: the parasitic and the predaceous. The former lay eggs in the bodies of their chosen host, and these eggs hatch into small maggots which live on the vital tissue of the host until this feeding finally kills the latter. When the host is dead, the maggot will have gone through its transformations and emerge a mature insect. The predaceous insects are those which eat their prey bodily. For instance, the well-known praying mantis, and the more familiar ladybird, belong to this class.

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Beneficial insects are at work every day destroying those which do harm to the vegetable world by feeding on them. These insects do not eat foliage, neither do they suck the sap in the leaves, depending for their sustenance upon other insects.

Many species of beneficial insects have been especially brought from abroad to cope with injurious insects introduced from the same country, but, unfortunately, without the phenomenal success of the *Vedalia cardinalis*. Many factors enter into the successful colonization of beneficial insects: climate and hyperparasites being the chief. The hyperparasites (those insects which are in turn parasitic upon the beneficial insects) are often or nearly always introduced with the latter, and if conditions are good for the beneficial insects they soon become so for the hyperparasites. The greater the reproduction among the beneficial insects, the larger the colony of hyperparasites becomes, until in many cases the work of the beneficial insects is nullified, or, at least, checkmated by their own insect enemies.

It will be seen, therefore, that while Nature attempts to maintain an even balance, it cannot do so exclusively without the aid of man. If transportation systems did not exist, then there would be no foreign species in any country. Each country would have, and its vegetable world would maintain, its own native

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injurious insects, and these in turn would form a sufficient food supply for their natural insect enemies. Now, however, man has upset Nature's nicely calculated balance of things, and so, as a result, has had to develop sure means of controlling those insects which would otherwise have had conditions entirely in accordance with their own food requirements.

Chemists and entomologists have worked side by side until a number of chemical formulæ have been developed, with which vegetation may be sprayed to prevent the depredations of the injurious insects, and to control diseases.

The habits of insects have been studied, and, for the purpose of controlling them, they may be said to be divided into three classes:

1, those with biting or chewing mouth parts (the leaf eaters); 2, those with biting mouth parts which bore into wood and, 3, those with sucking mouth parts which imbibe the sap in plants and in that manner devitalize them.

Of the leaf eaters, or those with biting mouth parts, such as caterpillars and beetles, the two most prominent and universally known are, perhaps, the tent caterpillar and the elm leaf beetle. Insects under this class can be controlled only by spraying the foliage—their food supply—until it is covered with a fine, even coating of some stomach poison, such as arsenate of lead. These leaf-chewing insects eat large holes in the center, along the edges, or

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may completely skeletonize the foliage, according to the species. Their work naturally reduces the feeding and breathing surfaces of the plants affected, causing devitalization. In certain sections, the elm leaf beetle will, after a couple of weeks' feeding, reduce an avenue of beautiful elms to a mass of brown, skeletonized leaves, with no trace of green foliage.

The second class also includes insects with biting mouth parts, but these insects are not foliage eaters. They confine themselves to boring or tunneling into the woody parts of trees, or in girdling the trees under the bark. The two most notable examples of this class are probably the bronze-birch borer and the peach-tree borer. Insects of this class gain their nourishment either by extracting it from the bits of wood and bark which they swallow in their burrowing, or from the sap. The method of gaining nourishment depends on whether the particular insects feed in the sapwood or in the deadwood.

Their depredations, when they burrow into a tree, admit moisture which causes rot, or wood-destroying agents gain entrance with the same results: *i.e.* the wood decays, a cavity is formed, the structural strength of the tree is weakened, and it may finally die. Those insects which live in the cambium usually completely girdle the tree, the supply of sap is cut off and, naturally, the tree dies.

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Various materials have been suggested for the control of these boring insects, but preventive measures are far more to be recommended. Borers rarely attack healthy trees, and as a tree soon shows signs of ill health, either in the color or sparsity of its foliage, such trees should receive the immediate attention of one well versed in the science of tree care. Feeding a tree will often be of direct benefit in checking the depredations of borers. At the entrance of their burrows there is invariably a collection of frass and sawdust which shows the approximate location of the intruder and, if only one or a few trees are slightly infested, it is a good plan to take a piece of fairly stout wire, pointed at one end, and pass it up the burrows. This will pierce and kill the borers. When trees are badly infested, it is sometimes advisable to cut out such trees and burn them, but severe measures like that should not be adopted unless under the advice of a tree expert. It might be that such a drastic procedure would be the best course in order to save the other trees.

When borers attack the limbs of trees, the dead limbs should be cut back to the live and, if possible, uninfested wood, and the débris immediately burned. The time of year to do this varies with the insect and its life cycle.

Another method for the control of borers is to inject carbon disulphide into their burrows and plug the entrances with putty. This

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method is particularly to be advocated for those borers which make winding burrows.

The trunks of trees—from just under the surface of the soil to as high as practicable—should be examined in the spring and fall for signs of borers, and then prompt action should be taken to determine the species and best method and time of control.

The third class of injurious insects—those with sucking mouth parts—must be controlled by an entirely different method. In piercing the foliage to imbibe the sap which is under the epidermis, these sucking insects would not take any stomach poison into their intestinal tract and, therefore, any such poison which was coated on the foliage would have no effect on them. They have, however, a vulnerable point, or rather points, as their breathing spiracles open on the sides of their bodies, so that a material must be used which will either liberate a deadly toxic gaseous vapor, or one which will clog the spiracles and cause suffocation. For this purpose one may either use a nicotine dust or nicotine sulphate, both of which release a toxic gas, or a special spraying oil, of which there are many brands on the market, which will clog up the breathing apparatus and cause death.

The effect of the feeding of these sucking insects is to give the foliage a mottled appearance (this is not, however, indicative exclusively

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of the presence of sucking insects, but may be due to a fungous disease), and, if the infestation is heavy, the plants become devitalized and may die.

Spraying materials should always be applied in *strict accordance with the manufacturer's recommendations*, as each material differs somewhat in its formula and in its action both on the type of plant to be sprayed and on the insect.

Some trees are very susceptible to oil sprays at any dilution. For instance, peach foliage should never be sprayed with oil, although during the dormant season peach trees may be sprayed with oil to control scale (a sucking insect) or the eggs of insects.

There are many types of spraying apparatus, and it may generally be assumed that each is good for the purpose for which it was manufactured. A small knapsack sprayer is excellent for spraying plants, shrubs, and some low-growing trees, but would be absolutely useless for spraying high trees like the elms, maples, etc.

Shade trees undoubtedly require power apparatus in order to be properly sprayed, and if spraying is not done *thoroughly* it might as well not be done at all, as many insects reproduce at an alarming rate. Unsprayed portions of an infested tree form excellent breeding places. A barrel sprayer is scarcely effective

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for work on shade trees even with a sufficient length of hose to allow the operator to climb into the tree, as it lacks the power to throw a fine mist.

Unfortunate as it may seem, there is nothing to be done but to use a power sprayer with a spray gun and nozzle which will break up the spray into a fine mist. A coarse spray is like a steady stream—it will knock off only those insects which it hits.

The foliage should be thoroughly and evenly covered on both the upper and lower surfaces, if a good job of spraying is done. Some insects, however, such as the maple aphid, congregate on the under sides of leaves and, naturally, greater care would have to be exercised to cover adequately all the under sides of the foliage.

Timeliness and thoroughness are the two essential factors which contribute to make spraying successful. Spraying is not an expensive operation, and there can be but little excuse for neglecting to keep trees free from injurious insects.

Instances occur when for no apparent reason a tree becomes devitalized and sickly in appearance. Often this is due to scale insects which somewhat resemble the bark of the tree on which they are feeding. These insects are small and, for the greater part of the year, they are fastened to the tree, remaining in that posi-

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tion until and often after death, and are not usually observed by the amateur. Spraying with miscible oil, lime-sulphur solution, or fish-oil soap is usually effective.

Banding unsprayed trees is practically useless except to prevent crawling insects from going above the bands, but the majority of foliage-feeding insects are winged at one time of their life cycle and, naturally, with the instinct for the preservation of their kind, they lay their eggs where the next generation will have a food supply—up in the crown of the tree. After a tree has been thoroughly sprayed, a sticky band placed around the trunk has certain distinct advantages in that it will prevent any caterpillars on the ground from proceeding to the foliage above. Sticky bands require renewing from time to time, as otherwise they become dry, coated with dust, etc., and a pathway is thus made for the insects to cross in safety.

Fungicides are chemicals which have been specially developed for use in combating fungous diseases. Generally speaking, Bordeaux Mixture or lime-sulphur solution (the latter is also an insecticide) are the two most universally used fungicides. In the matter of fungous diseases, it would be impossible within the scope of this book to deal with the various fungi and symptoms of disease. The injury caused by some fungi is almost the same as that

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caused by certain sap-sucking insects, and in others there are characteristic markings on the affected leaves.

Many tree ailments will be attributed to fungous diseases by the inexperienced. There is no easy rule to guide one to tree ailments and, therefore, it is often necessary to consult an expert who, after an examination of any given tree, will usually be able to diagnose its trouble and prescribe for its treatment.

Fungi are the lowest form of vegetable life, but unlike other plants they lack chlorophyll and, therefore, they must obtain their food from living or dead wood and animals. Their food classifies them as parasites when they feed on living tissues, and as saprophytes when on dead tissues. When fungi are found living on live wood they are producing decay and must be extirpated. There are two stages in the life of fungi: one is known as the vegetative or mycelium stage during which they feed, and the other is the spore stage. For determination of the species of fungi the latter stage must be examined, as all mycelium of fungi are too much alike for an accurate diagnosis.

After the mycelia, which are microscopic branched threads, once gain entrance to their host, no amount of spraying will kill them. A fungicide to be successful must be applied before the spore shooting takes place.

Cavities and Cavity-Filling Materials

Cavities are very easily formed in trees. They may be due to animals gnawing the bark, to mechanical or physical injuries, to unprotected pruning cuts, to defective pruning, or, in fact, to any cause that would expose the cambium layer or heartwood to infection by wood-destroying agents. Even with proper pruning decay will set in unless the cuts are repainted every year or two.

Undoubtedly by far the greater number of cavities are due to defective pruning. A stub not cut at the collar soon dries out and splits, and the cracks form suitable hibernating places for insects, for the collection of moisture, and the formation of yeasts, and in a short while there is a large diseased area in the tree.

Any injury that affects or exposes the cambium layer or heartwood should receive the attention of a qualified tree surgeon immediately, in order to save the expense consequent upon what would be the inevitable formation of a cavity.

Cavities are the result of neglect in not promptly treating any injury or extirpating boring insects.

The need for tree surgery may be obviated in part by having trees with poor formations

Cavities and Cavity-Filling Materials

properly braced to prevent their splitting at the crotch, or in having old limbs cabled so that they may be strengthened by being held together.

One often hears the complaint that tree surgery is too expensive. In defense, it may be suggested that tree surgery is only necessary where trees have suffered mechanical or physical injury or neglect, and that the tree expert (a title that has been indiscriminately applied to all types of tree workers) is, or should be, a man who has had definite training. Training, experience, tools, materials and time are well worth the modest remuneration usually asked for, particularly when the work, properly executed, saves a tree which it would take years to replace. This naturally leads to a monetary evaluation of trees, and there can be no doubt that the trees add very much to the value of real estate, both from financial and æsthetic points of view.

The purpose of tree surgery is to strengthen trees structurally when necessary, and to prevent reinfestation and reinfection of a cavity by filling it.

The choice of a filling medium is a much discussed question among the experts, and is one about which every person contemplating the employment of a tree surgeon should be informed.

Nothing will prevent decay so well as sun-

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light or charring. Experiments in charring have been most gratifying on a small scale, but the methods of commercializing the work have not been perfected.

In the past many cavities have been filled with Portland cement and sand, and in some cases the external appearance of the cavities may seem perfect, but at the back of the filling the wood would probably show a different condition. Cement is foreign to tree growth; there can be no possible union between cement and the wood of the tree. The result is that after cement has been put into the cavity, and the filling has dried, it contracts during the process of dehydration, and instead of sealing the cavity small spaces are sometimes noticeable between the edge of the cement and the tree—excellent points for reinfestation. Moreover, cement is heavy and when placed in a limb, it contracts and rests as a solid weight, resisting the natural swaying of the limb, with the result that it is soon like a loose filling in a tooth, serving any but a useful purpose.

Cement was first put in trees in solid blocks, but it was found that it could not thus withstand the swaying of the trees without cracking. By a later development it was put in by sections, with somewhat better results, but it is now generally considered that the majority of cement-filled cavities are defective. (Fig. 5.)



FIG. 6. Beech tree showing vertical cavity with all diseased wood removed. Note how the cavity is shaped at the top. Cambium layer has been shellacked and the cavity is ready to receive the filling.



FIG. 7. Beech tree shown in Fig. 6 with cavity filled with rigid material.

Cavities and Cavity-Filling Materials

Asphaltum mixtures are composed usually of asphalt, sawdust or excelsior, or in some cases sand. The asphalt must be heated after which the other ingredient is stirred in. The mixture is poured into the cavity and allowed to harden. In an upright cavity bricks of the material would have to be made first for the facing of the cavity and then the hot mixture is poured. When put in hot it shrinks during the process of cooling or hardening leaving an opening around the edge and it is necessary to fill up this space. The effects of the hot summers soon soften the surface causing the filling medium to pull away from the edges when it re-hardens.

Another material which is used extensively is an admixture of magnesite, sawdust, and magnesium chloride. This expands and contracts almost in unison with the tree. It has the disadvantage of being heavy, and when used for filling a cavity in the base of a tree that portion which comes into direct contact with the ground deteriorates and crumbles. (Figs. 6 and 7.)

There are three natural substances on the market for filling trees: namely, cork, a treated gum from coniferous trees, and wood strips.

Cork has much to recommend it for certain types of cavities. It comes, of course, from cork trees, and it is light, durable, and elastic. This material is cut in strips of varying length, but of uniform thickness and height, and each

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strip has a number of holes punched in it which are filled with a chemical crystal to prevent borers from attacking the cork. There would seem to be some question as to why the strips should have the chemical crystals. These require moisture in order to release a gas which would be toxic to wood-boring insects, but with the outer surface of the cork waterproofed with paraffin wax it would or should prevent moisture from penetrating to the crystals. Even if moisture penetrated to the crystals the gas would be released and the crystals would be ineffective after a few months. The cavity is prepared in the usual manner except that the edges must be perfectly smooth and beveled. The cork strips are cut to fit tightly into the cavity (slightly oversized), and the facing with the strip cork is started from the bottom upward. Each layer is agglutinated or held together with pitch, and when two or three strips have been put into the cavity, a granulated form of cork is filled in at the back, first having been mixed with some mastic, and the process is repeated until the cavity is filled. Then the surface is painted with creosote and, as soon as that dries, the cork is waxed over. Cork fillings look very attractive, and so far as they have been tried, are satisfactory. Some of the cavities, however, which were treated several years ago with cork blocks were not so satisfactory, but research has improved cork

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fillings to their present stage. The elasticity of the cork permits the natural swaying of the limbs with the filling.

The second natural filling mentioned above is obtained from coniferous trees in the form of a gum which they exude from wounds. This gum is treated with a disinfectant and anti-septic, and when filled in small cavities it congeals but does not harden. As the cambium layer starts to close over a cavity filled with this gum the filling will be partially squeezed out, so that it will completely protect the filled-in area until the cavity has healed over the entire surface. This material, undoubtedly, forms an excellent protective covering as well as filling medium, and could be used to advantage as a pruning paint, or as a material for treating the back and sides of large cavities in which it would not be practicable to use it as a filling material. Obviously, it would not give any support to a tree which had a large cavity, and could therefore only be used as a filling medium in small cavities.

Filling cavities with wood strips is to be commended, as it has three distinct advantages, *i.e.*, natural filling medium, and flexibility combined with strength.

For wood strips the cavity is prepared in the same manner as for any other filling medium. The strips are securely fastened to the back and sides of the cavity longitudinally, and the

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remainder of the cavity is filled in with strips whose adjacent sides and ends overlap and bind them securely in position, and any joints or spaces are filled with an antiseptic and waterproofing mixture.

The greatest part of the expense in cavity treatment is due to the time involved in removing all diseased wood, it being necessary to cut back to the healthy wood before a filling should be put in.

When only clean, healthy wood is left it should be disinfected with creosote, care being taken to avoid getting any of this on the cambium layer. Waterproofing should be done as cement gives off heat more quickly than wood, therefore it is colder at all times than the surrounding wood. There is a condensation of moisture around the cement and as it accumulates it seeps out between the cambium and cement as there is no adhesion or union between the cement and the wood. Without waterproofing of the back and surface of a filling there is a possibility of sap collecting at the back of the cavity, making an ideal spot for the development of yeasts, but this question of waterproofing is a moot one. Some believe that if sap is to collect in a cavity it is better to have it remain in a disinfected position back of the filling than to allow it to seep at the base of the cavity where fungous spores would most certainly germinate. If the filling material is

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of the same temperature as the tree there would be no accumulation of sap or moisture. From a pathological viewpoint the greatest criticism of concrete is its coldness, as it attracts moisture which is given off as leakage down the trunk of the tree.

Cavities, if large, may require bracing with rods. Nails are usually driven into the back to hold the filling medium, particularly if the latter is of the "rigid" type, *i.e.* cement or magnesite. It is necessary to pack or fill in either of these materials in layers, and as each layer dries the next is added until the whole cavity is filled.

No filling material of any nature should be filled in over the cambium, as this would stop the natural roll of the cambium over the edges of the filling material.

During the chiseling of the diseased wood, the cavity should be shaped so as to insure an even healing of the cambium. All cavities should be more or less pointed at the top and bottom, as the flow of sap tends to follow a straight up-and-down path. Sap will not flow over any portion of a filled area which is horizontal, with the result that the living cells in that portion would not be fed and would naturally die; and as that portion of the cambium would not heal over the edge of the filling medium, the wood would rot in time and another cavity would form. When the

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cambium has been cut to the necessary shape it should be shellacked immediately.

Split trunks invariably require to be held taut by means of rods.

All cavity fillings require waterproofing on the surface. In the case of cork this is done with melted paraffin wax. With other fillings the surface is painted with a waterproof paint.

Contract work in tree surgery, *i.e.*, cavity work, should be avoided. It is impossible for a tree surgeon to tell just how much time will be required to remove all diseased wood, and often after a cavity has been opened up there will be exposed a much larger area of diseased wood than would be suspected from the external appearance of the cavity. When a contract for cavity work is given, the tree owner may be assured either that the price set is high enough to protect the estimator, or that in case it is not, the tendency will be toward a poor job, which would mean that all of the diseased wood might not be removed and that the tree would be hastily filled. Time plus material is the only fair basis for cavity work, both for the customer and the tree surgeon. Other phases of tree work may be readily and accurately estimated, and may therefore be done on a contract price.

Some tree surgeons prefer to treat smaller cavities, or cavities in old trees which would not be worth filling, as open cavities. Such a cavity is treated in the same manner as if it were to be filled. All dead and diseased tissue

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is gouged out, the cambium shaped and shellacked, and then the newly exposed wood is treated with an antiseptic and disinfectant. These open cavities are so shaped that natural drainage is provided in order that rain water, etc., cannot collect.

Sap does not accumulate at the back of waterproofing in an open wound.

There are several definite objections to open cavities. They are unsightly, and need to be inspected at least yearly and repainted when necessary. They naturally do not add anything to the structural strength of the tree, and where bracing through the shell of the tree is done, the bolts do not look very attractive. A further disadvantage is that the treatment for open cavities is practically no cheaper than that for filled cavities, because the same amount of time would have to be spent in removing the dead or diseased wood, and there would be only a slight saving on filling material.

Some trees are not worth cavity work, in particular old silver maples. From such trees it is best to have all the deadwood taken out in order to improve their appearance, and they should be heavily cut back. Young nursery stock should then be interplanted, so that when the older trees finally die the young ones will be established. The purpose of the heavy cutting back of the old trees is to permit sufficient sunlight and air to reach the newly planted nursery stock.

Some Ailments of Trees

Shade trees, as well as requiring pruning, fertilizing, and cavity work, and being subject to attacks of insects and fungous diseases, are afflicted with a number of other ailments, some of which are easily diagnosed by an amateur, and others which are difficult of determination even by an expert.

If a tree is sickly from any cause it is soon observable by its foliage. When the leaves turn yellow out of season, when they droop or dry up and crinkle, or when the foliage is sparse, these are the outward and visible signs of ill health, and then the tree demands the attention of one well versed in tree life with its multitudinous troubles.

When trees are obviously sick is not, of course, the only time at which they should receive attention. The old adage "a stitch in time . . ." can very well be applied to trees, and preventive measures are much better and cheaper in every sense *than curative attempts*.

Gas Poison. A frequent cause of ill health and death of trees is due to leaking gas mains or sewers in close proximity to their roots. This form of injury is not quickly discernible, as the

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roots first become affected and the foliage later. By the time the foliage shows signs of gas poisoning it is generally too late to save the tree. If there is any possibility of a leak in a gas main or sewer, a hole about two feet deep should be made with a crowbar three or four feet away from the trunk, and by smelling the entrance one can readily detect the gas. Gas poisons and kills the root system quite rapidly, depending upon the quantity escaping, the texture and moisture of the soil, and the covering that might be on the surface, such as sod or cement. The remedy, if the cause of the trouble has been located in time, is obvious. The leak must be found and repaired immediately. It is a good plan to dig a trench around a tree suffering from gas poisoning, care being taken not to injure the roots when digging the trench, and the trench should be left open. The soil in the trench, after the gas has been liberated, should be watered thoroughly and, after a few weeks, fresh topsoil should be filled in the trench. It will be advisable in some instances to prune the root system, and to cut back the top of the tree. These measures will be effective only where the gas has not penetrated over the entire root system, in which case the tree would be doomed.

In addition to leaky gas mains and sewers, there are many other causes which will adversely affect the root systems of trees. If

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a tree has been over-fed, or the fertilizer has contained too great a percentage of nitrogen in the form of nitrates, the tendency is to interrupt the taking up of soil moisture with a corresponding bad effect on the tree, or the excess of nitrogen may affect the branch system by exciting growth when winter killing would probably result. Few trees, however, suffer from over-nutrition, the majority, unfortunately, being affected with malnutrition.

Trees suffer as much, if not more, from too much water than from an insufficiency. Too much moisture in the soil cuts off the air supply to the roots, and too little moisture causes the roots to dry out. In seasons of unusually heavy rain or drought, it is difficult to keep the soil in proper condition, though it is easier during a period of drought than one of excessive rain. In the former case the soil should be aërated by boring a number of holes with a crowbar and "puddling" these by putting the garden hose in each and allowing the water to puddle; the trees should then be properly fertilized in order to stimulate growth. In the latter instance, aëration of the soil will be of direct benefit to a water-logged tree and, when possible, soil drainage should be made.

Frost cracks. In many instances when extremely cold weather follows a late-growing season trees split vertically, forming what are known as frost cracks. These usually occur after heavy freezing has frozen the moisture in

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the cells of the sapwood. The center or heartwood of the tree is naturally not so readily affected by a change of temperature owing to the insulating quality of the intervening wood, and as a result there is a much faster expansion of the moisture cells in the outer wood which causes the tree to crack with a characteristic vertical split. These frost cracks remain open as long as the cold weather lasts, closing when the temperature rises, until in the spring the bark invariably heals over. There is then a weak spot in the tissues thus expanded, and the crack invariably reopens the following winter. Loose wood should be scraped and the cambium should be cut with a sharp knife so as to be V-shaped at top and bottom, and the exposed wood should be painted with a pruning paint. It will be noticed that these frost cracks usually occur on the southwestern side of the trees where the change of temperature is greater.

Winter killing. Winter killing of young growth is due to mild, warm weather in fall followed by severe, low temperatures. White pines, arborvitæ, and spruce are very subject to winter killing. Another type of winter killing is due to the freezing of the cambium and its consequent horizontal rupture by ice formed at the base of the tree or shrub. This may best be avoided by slightly sloping the ground, forming a natural drainage, and thus preventing the collection of water.

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